Silicon photonics and Novel Materials for Datacenters and Cloud Computing

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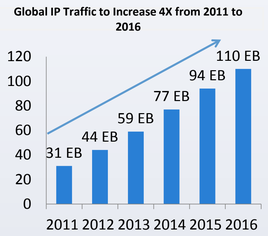
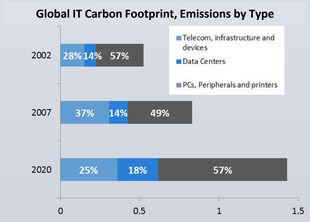
The problem:



There is tremendous growth in internet traffic and bandwidth demand due to the emergence of cloud computing, social media and internet video streaming applications.

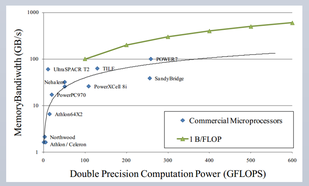
- This leads to service providers to build data centers on a huge scale.

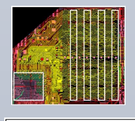
amazon.com YouTube Google facebook Microsoft NETFLIX



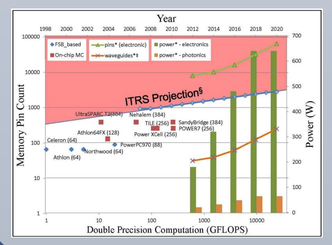
- The demand means ever-growing energy usage and green-house gas emissions. Global IT already has a greater carbon footprint than the airline industry.

Improving computational performance and efficiency is key to reducing emissions





- Complex Wiring
- High energy dissipation
- Large pin count



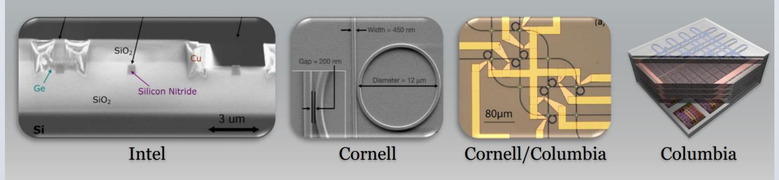
- However it is becoming difficult to improve computational efficiency using electronics.
- There is a bottleneck to send data from the CPU to memory or other computers.
- Combining optics with electronics can offer dramatic improvements in efficiency, as well as increases in performance

Silicon photonics vision:

Leverage the tremendous bandwidth available in fiber optic communications to solve CPU-memory and datacenter scale communication bottlenecks.

Silicon-on-insulator (SOI) platform photonic building blocks:

High index contrast enables high confinement, low-loss propagation, virtually lossless bending



Current efforts are on-going to make nano-structures that can manipulate light to replace electronic wires, filters, modulators, detectors, and switches, as well as coming up with new system designs leveraging photonics.

Commercial integration is nearly ready

Hybrid platforms

intel

Monolithic CMOS Integration

IBM

ORACLE

Transceivers for Datacom

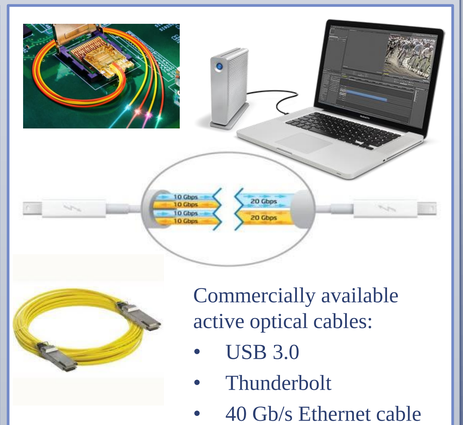
LUXTERA MAKING PHOTONIC INTEGRATION ECONOMICS LIGHTWIRE

Academic Foundry Services

imec Institute of Microelectronics A*STAR

OpSIS

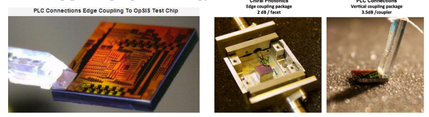
- Standardized manufacturing
- Component libraries
- Layout tools
- Wafer level processing and test



Commercially available active optical cables:

- USB 3.0
- Thunderbolt
- 40 Gb/s Ethernet cable

Maturing packaging technology:



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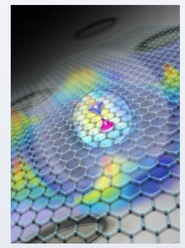
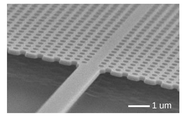
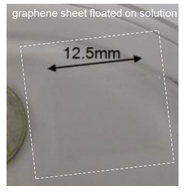
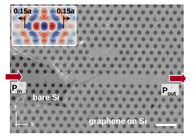


- Cross-disciplinary approach allow us to explore performance of novel structures and materials not examined before in Silicon Photonics.
- These materials offers intriguing properties for even higher performance and lower power consumption in Silicon Photonics.

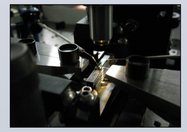






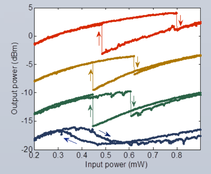
Fabrication of graphene on air-bridged silicon photonic crystal membranes:

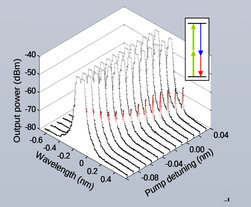
- First fabricate photonic crystal and waveguide on SOI using electron beam lithography and reactive ion etching
- Next grow graphene using chemical vapor deposition
- Transfer graphene by floating membrane on wet solution then drying
- Monolayer of graphene is deposited on the photonic crystal
- Light is strongly confined to waveguide region



Our collaboration allows us to leverage strengths in both device physics and systems level electrical characterization

Results





- Femto-joule optical bistabilities - steady-state hysteresis, useful for dynamic optical switching
- Optical nonlinearities in hybrid graphene-silicon cavities - enhanced Kerr and two-photon absorption observed
- Graphene-Si: cavity four-wave mixing – observations possible due to strong optical confinement, effective n_2 calculations and coupled-mode theory comparison to simulation

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